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Abstract

This paper argues that the large reduction in corporate tax rates and only gradual widening of tax bases in many countries over the last decades are consistent with tougher international competition for foreign direct investment (FDI). To make this point we develop a model in which governments compete for FDI using corporate tax rates and tax bases. The model's predictions regarding the slope of policy reaction functions and the response of equilibrium tax parameters to trade costs and market size are shown to be consistent with panel data for 43 developed countries and emerging markets. Using estimated policy reaction functions we simulate the effect of regional trade integration and find that this integration has contributed significantly to the observed fall in corporate tax rates.

JEL-Code: F150, F230, H200, H250.

Keywords: corporate taxes, tax competition, foreign direct investment, multinational firms, free-trade areas, regional integration.

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1 Introduction

Corporate tax systems in the developed countries have undergone dramatic changes over the past decades as statutory tax rates have fallen and tax bases have only gradually widened. We argue that these changes are largely consistent with tougher competition specifically for foreign direct investment (FDI). We make our case in three steps. First, we develop a model in which countries set both corporate tax rates and bases to compete for FDI. This model generates testable predictions concerning the slope of policy reaction functions with regard to the tax rate and the tax base, and links changes in equilibrium tax rates and bases to observable industry and country characteristics. Second, we use data on corporate tax systems in 43 countries (OECD members plus a number of emerging markets) to test the model's predictions. Third, we apply the estimated model to assess what role regional integration has played in the increase in tax competition and to what extent it is responsible for the observed changes in the tax system.

Median statutory tax rates in our sample of industrialized countries and emerging markets have drastically declined to less than 30% in 2005 from around 50% in the early 1980s. At the same time, the median tax base has become somewhat broader, as reflected in a gradual decrease in depreciation allowances. The overall effect, as confirmed by Devereux et al. (2002) for OECD countries, has been a reduction in the effective average tax rate since the early 1980s, while the effective marginal tax rate has remained more or less stable. This downward trend in the effective average tax rate is consistent with more intense competition for mobile multinational enterprises, since the profitability of a plant location depends on the average rather than the marginal rate. Tougher tax competition for portfolio capital, by contrast, would have suggested a fall in the effective marginal tax rate (see Devereux et al., 2002).

To develop stylized facts about the strategic interactions, if any, that take place when countries set tax policy it is useful to take a look at the unconditional correlations in domestic and foreign tax instruments reported in Table

1.[1] Foreign and domestic tax rates are positively correlated, as are foreign and domestic depreciation allowances. However, foreign (domestic) tax rates and domestic (foreign) depreciation allowances are negatively correlated. A lower foreign tax rate is thus associated with a lower domestic tax rate but a higher domestic depreciation allowance. This suggests that countries might react to a fall in their competitors' tax rates by cutting their own tax rates and narrowing their tax base. Needless to say, this reaction pattern at the micro level is obscured by the aggregate figures which show a drop in the median tax rate but a slight widening of the median tax base over the years.

The current paper offers a simple explanation for the observed reaction pattern based on competition for discrete investment projects by multinational enterprises. Specifically we posit a world in which governments have to deal with two basic issues. First, due to market power, domestic firms and multinationals underinvest and thus produce too little output from the point of view of social welfare. Second, profits of multinationals not captured by source-based taxation may be repatriated to foreign owners. In response to these issues, a welfare-maximizing government will implicitly subsidize capital through a low effective marginal tax rate and capture a share of the multinationals' profits by making its effective average tax rate as high as possible without deterring the investment projects. When a rival government reduces its tax rate or grants a more generous depreciation allowance, the best response is to reduce the effective average tax rate while keeping the effective marginal tax rate constant. This can be achieved by lowering the corporate tax rate while increasing the depreciation allowance. Our model

[1] See Section 5.4 for further details. Foreign tax instruments are computed as the weighted average of instruments for each country's competitors. Weights are based on potential (predicted) bilateral commodity trade flows. All regressions include country fixed effects but no other covariates. Standard errors are robust to heteroskedasticity and serial correlation. Correlations should not be interpreted as reaction function parameters, since the lack of fundamentals leads to inconsistent Nash tax rates.

thus generates the observed negative correlation between changes in tax rates and depreciation allowances in response to shocks in the degree of competition for FDI. Our empirical analysis shows that this best-response pattern of countries is confirmed by the data.

By simultaneously considering changes in tax rates and depreciation allowances our paper refines the classical literature on tax competition, in which tax rates are the only policy instrument (see Wilson, 1999, and Wilson and Wildasin, 2004, for surveys of the literature). Another deviation from this literature is the focus on competition for discrete investment projects, which seems appropriate given the observed fall in effective average tax rates and stability of effective marginal tax rates. Closely related papers are by Haufler and Schjelderup (2000) as well as Devereux et al. (2008), which also feature governments that compete for FDI using tax rates and depreciation allowances.[2] These two papers offer an explanation for the change in corporate tax systems that is complementary to ours. They argue that countries are forced to reduce corporate tax rates in response to attempts by multinational enterprises to use transfer pricing to shift profits to the lowest-tax location. Countries simultaneously reduce depreciation allowances either because they face a fixed tax revenue requirement and need to make up for the loss of revenue stemming from the lower tax rate (Haufler and Schjelderup, 2000), or because they are large and want to strategically depress the world price of capital (Devereux et al., 2008). Both papers have in common that changes in tax rates and depreciation allowances are positively correlated, which is in contradiction to the stylized facts presented in Table 1 above.

In our theoretical model, the degree of tax competition depends, among other things, on the degree of regional integration. Regional integration, by reducing trade costs between countries, induces tougher competition in cor-

[2] See also Becker and Fuest (2009), and Osmundsen et al. (1998). In these two papers, governments set tax rates and depreciation allowances to discriminate between firms with different productivity, resp. mobility costs. Janeba (1996) considers the use of tax rates and depreciation allowances to shift profits between domestic and foreign firms. Bauer et al. (2011) examine the effect of economic integration on tax rates and bases in a theoretical model with heterogeneous firms.

porate tax rates and depreciation allowances. We investigate whether the observed changes in tax policy are consistent with regional integration by using our empirical model to construct several counterfactual scenarios in which regional integration agreements in Europe and North America are absent. Our simulations show that without the regional trade agreements tax rates would indeed have been significantly higher and depreciation allowances a bit smaller, suggesting that regional integration may be one of the underlying reasons for the observed policy changes.

The rest of the paper is organized as follows. Section 2 presents a simple model of tax rate and tax base competition for FDI to demonstrate the workings of our tax competition mechanism and derive testable predictions concerning the slope of reaction functions and comparative static effects. In Section 3 we characterize the Nash equilibrium taxes and depreciation allowances. Section 4 derives comparative static results, and Section 5 contains the empirical analysis. In Section 6 we use the empirical model to simulate the effects on tax policy of regional integration agreements. Section 7 concludes. The Appendix contains proofs and data sources.

2 The Model

We consider a region consisting of two countries, labeled home (H) and foreign (F). Multinational firms, owned by residents in the rest of the world, are mobile between the two countries, whereas households and national firms stay put. In order to focus on discrete location decisions of multinationals, we assume that capital markets—capital being the only factor of production—are perfectly integrated across the world, but product markets are segmented by trade barriers.[3]

[3] Our theoretical model builds on papers by Haufler and Wooton (1999), Raff (2004), and Bjorvatn and Eckel (2006); but these papers consider only tax rate competition for FDI. A related paper examining competition in two policy instruments, in this case taxes and performance requirements, is by Davies and Ellis (2007).

2.1 Households

We assume that H has a measure $n \geq 1$ of households, whereas the measure of households in F is normalized to one. Households in H and F have identical preferences. Each household residing in country $j = H, F$ consumes a numeraire good y_j and a continuum of differentiated goods $q_j(i)$, $i \in \Omega_j$, where Ω_j is the set of differentiated goods available in j. The utility function of a household residing in j is given by

$$U_j = y_j + \int_{i \in \Omega_j} \left[q_j(i) - \frac{1}{2} \left(q_j(i)\right)^2 \right] di. \tag{1}$$

The numeraire goods is competitively provided in each country, whereas the differentiated goods are produced under imperfect competition. Production of a unit of the numeraire good requires exactly one unit of capital. Hence the price of capital is equal to one in both countries. The numeraire good can be transported freely across countries, so trade is always balanced.

Each household in country $j = H, F$ inelastically supplies one unit of capital each. The household also receives profit income, π_j, from the domestic firms it owns and tax revenue R_j, which is redistributed by the government in lump-sum fashion. Denoting the consumer prices of the differentiated goods sold in country j by $p_j(i)$, a household's budget constraint is

$$y_j + \int_{i \in \Omega_j} p_j(i) q_j(i) di = 1 + \pi_j + R_j. \tag{2}$$

Maximizing utility subject to the budget constraint yields the household's demand curves

$$q_j(i) = 1 - p_j(i). \tag{3}$$

Denoting total sales in country j by $Q_j(i)$ we can write inverse market demand in the two countries as

$$p_H(i) = 1 - \frac{Q_H(i)}{n} \quad \text{and} \quad p_F(i) = 1 - Q_F(i). \tag{4}$$

Markets in the two countries are segmented so that firms can set prices independently in each market.

2.2 Firms

Each firm specializes in a single industry i, so that each differentiated good is produced by a monopolist. We distinguish between two types of firms, multinationals and domestic firms, and assume that a positive fraction of firms is multinational. Multinationals are owned by residents in the rest of the world and seek to locate a production plant in either H or F from which to supply the whole region.[4] Domestic firms in H and F are owned by local residents and immobile across countries; each domestic firm has a plant in its native country from which it may also export to the other country. Otherwise domestic firms are identical to multinationals. In particular, each firm requires $c < 1$ units of capital per unit of output, so that c can be interpreted as the marginal cost of production. The per-unit trade cost between countries, denoted by s, is sufficiently small to guarantee positive exports for each firm, i.e., $s < 1 - c$. In the remainder of the paper we drop industry identifiers whenever possible.

2.3 Governments

The governments of H and F choose tax policy to maximize the utility of the households under their jurisdiction, or social welfare for short. Social welfare consists of the sum of tax revenue and consumer surplus. Each government has two policy instruments: a source-based corporation tax on profits, τ, and a depreciation allowance, δ, that determines the tax base; F's policy instruments are identified by an asterisk (*).[5] Hence the tax paid by a (multinational or domestic) firm located in country H and selling its output in both H and F is

$$\tau\left[\left(1-\frac{Q_H}{n}-\delta c\right)Q_H+\left(1-Q_F-\delta c-s\right)Q_F\right],$$

[4] It is implicitly assumed that there is a sufficiently large set-up cost for a plant (relative to the cost of transporting goods between H and F) so that it does not pay the multinational to have a plant in each country.

[5] We implicitly assume that the multinationals' tax payments in H and F are exempt from further taxation in their home countries. We revisit this assumption in the empirical part of the paper.

and the corresponding after-tax profit is equal to

$$\begin{aligned}\Pi_H &= (1-\tau)\left[\left(1-\frac{Q_H}{n}\right)Q_H + (1-Q_F-s)\,Q_F - c(Q_H+Q_F)\right] \qquad (5)\\ &\quad -(1-\delta)\tau c(Q_H+Q_F).\end{aligned}$$

It turns out to be convenient to rewrite this function in terms of the effective marginal tax rate ($EMTR$) on capital, $\alpha - 1$, which we define as follows:

$$\alpha - 1 \equiv \frac{(1-\delta)\,\tau}{1-\tau} = \frac{1-\delta\tau}{1-\tau} - 1. \qquad (6)$$

After a simple transformation we hence obtain

$$\Pi_H = (1-\tau)\left[\left(1-\frac{Q_H}{n}\right)Q_H + (1-Q_F-s)\,Q_F - \alpha c(Q_H+Q_F)\right]. \qquad (7)$$

The corporation tax is hence equivalent to a pure profit tax, if $\delta = 1$ and therefore $\alpha = 1$. If $\delta > 1$ ($\alpha < 1$), more than the true capital cost can be deducted for tax purposes; hence capital use in production is implicitly subsidized ($EMTR < 0$). If $\delta < 1$ ($\alpha > 1$), the taxable cost is less than the actual cost, and the capital input is implicitly taxed ($EMTR > 0$). In the following we will work with α instead of δ. However, given the statutory tax rate and the $EMTR$ we can easily compute δ.

The reason why the governments will want to use two instruments to tax firms is that there are two "distortions": (i) as monopolists firms produce too little output, giving the government an incentive to subsidize production; and (ii) multinationals, being owned by foreign residents, will repatriate their profits unless the government captures them with a tax.

Governments are assumed to be able to commit to the policies they announce. For instance, if country j offers a low corporate tax rate to attract multinationals, it does not rescind its offer once the firms have made their investment.[6]

[6] The commitment problem and its effect on FDI has been extensively discussed in the literature (see, for instance, Bond and Samuelson, 1988, and Doyle and van Wijnbergen, 1994). The current paper has nothing new to add to this literature. We avoid the commitment problem by abstracting from sunk investment costs.

2.4 Timing

The strategic interaction between the governments and the firms can be represented by a sequential game with the following order of moves:

Stage 1: H and F choose their policy instruments simultaneously and non-cooperatively.

Stage 2: Firms observes these policies, and multinationals decide in which country to locate.

Stage 3: Firms choose output.

In the next section we characterize the countries' best response functions and the pure-strategy subgame-perfect equilibria of this game (equilibria for short).

3 Equilibrium

Taxes collected from domestic firms simply flow back to domestic residents, the owners of the firms, through the redistribution of government tax revenue. This implies that the optimal level of the profit tax in the case of domestic firms is indeterminate. Rather, profit taxes are set to attract multinationals. Specifically, governments have to take into account the participation constraints of multinationals.

Consider the participation constraint from the point of view of country H (obviously, the same reasoning applies to country F). A multinational will locate in H, if the associated profit exceeds the profit from locating in F. Hence the participation constraint for a multinational in H is:

$$(1-\tau)\frac{n(1-\alpha c)^2+(1-\alpha c-s)^2}{4}\geq(1-\tau^*)\frac{(1-\alpha^* c)^2+n(1-\alpha^* c-s)^2}{4} \tag{8}$$

Since social welfare is strictly increasing in τ, H will want to make sure that the multinational's participation constraint is binding. A binding participation constraint implies that the social welfare associated with a good produced by a domestic firm (consisting of the sum of consumer surplus and profit) exceeds the welfare generated by a multinational produced good by exactly $(1-\tau^*)\left[(1-\alpha^* c)^2 + n(1-\alpha^* c - s)^2\right]/4$, that is, by the part of the profit that cannot be captured by the corporate tax because the multinational would otherwise locate in F. Since this amount depends only on F's policy parameters, the optimal level of α is the same for domestic and multinational firms. Hence we can state the following result:

Lemma 1 *In equilibrium H chooses $\alpha = \bar{\alpha}$, and F sets $\alpha^* = \bar{\alpha}^*$, where*

$$\bar{\alpha} = \frac{2c - n + 2cn}{(n+2)c} \quad \textit{and} \quad \bar{\alpha}^* = \frac{2c + 2cn - 1}{(1+2n)c}. \tag{9}$$

Proof: see Appendix.

Note that $\bar{\alpha} - 1 < 0$ and $\bar{\alpha}^* - 1 < 0$ so that the optimal $EMTR$ is negative. That is, the government implicitly subsidizes investment to reduce the monopoly distortion and increase consumer surplus.[7] More importantly, the optimal level of α (α^*) depends only on marginal production costs and country size. Hence a government optimally responds to a change in its rival's tax policies by keeping its $EMTR$ unchanged and adjusting its corporate tax rate to satisfy the multinationals' participation constraints. This dramatically simplifies the characterization of the equilibrium policies.

Using $\alpha = \bar{\alpha}$ and $\alpha^* = \bar{\alpha}^*$ in (8) implicitly defines H's best response function in tax rates:

$$(1-\tau)\frac{n(1-\bar{\alpha}c)^2 + (1-\bar{\alpha}c - s)^2}{4} - (1-\tau^*)\frac{(1-\bar{\alpha}^* c)^2 + n(1-\bar{\alpha}^* c - s)^2}{4} = 0; \tag{10}$$

a similar function characterizes F's best response. This best response function has a positive slope, meaning that corporate tax rates are strategic complements. If country F lowers τ^*, so that the profit multinationals may earn

[7] Consider the $EMTR$ in H. Since part of the output is exported to F, the subsidy falls short of the level needed to reduce the domestic price in H to marginal cost c. However, it is easy to show that if the trade cost is prohibitive so that the entire subsidy falls on local output, the optimal implicit subsidy, $\bar{\alpha} = (2c-1)/c$, indeed induces marginal cost pricing.

when locating in F rises, H's government is forced to cut its tax rate to keep them from relocating.

To compute the equilibrium, note that given the rival's corporate tax rate, each country will try to lower its corporate tax rate just enough to attract the multinationals. For $s > 0$ and $n > 1$, H has a locational advantage relative to F, since with identical policies and positive trade costs multinationals prefer to locate in the larger market. It is easily verified that in equilibrium the government of F chooses the τ^* that makes it just indifferent between attracting multinationals and having them locate in H. H's government sets τ so as to attract the multinationals and extract the locational rent.

That is, F's government chooses τ^* so that welfare (consisting of the sum of consumer surplus and tax revenue) when a firm locates in F is just equal to welfare (i.e., the consumer surplus from importing the good) when the firm is located in H:

$$\frac{(1-\bar{\alpha}^* c)^2}{8} + \tau^* \frac{(1-\bar{\alpha}^* c)^2 + n\,(1-\bar{\alpha}^* c - s)^2}{4} - \frac{(1-\bar{\alpha}^*)c\,((1-\bar{\alpha}^* c) + n\,(1-\bar{\alpha}^* c - s))}{2} = \frac{(1-\bar{\alpha} c - s)^2}{8} \quad (11)$$

Substituting for $\bar{\alpha}$ and $\bar{\alpha}^*$ from (9), this equation defines F's equilibrium tax as a function $\bar{\tau}^* = \bar{\tau}^*(c, n, s)$.

H's government sets τ such that multinationals are indifferent between locating in H or in F. The equilibrium value of τ can be computed from (10) by setting $\tau^* = \bar{\tau}^*$ and using the expressions for $\bar{\alpha}$ and $\bar{\alpha}^*$. We denote the equilibrium tax rate by $\bar{\tau} = \bar{\tau}(c, n, s)$.

Given the equilibrium policies $\bar{\tau}$ and $\bar{\alpha}$ ($\bar{\tau}^*$ and $\bar{\alpha}^*$) we can use (6) to solve for the equilibrium depreciation allowance $\bar{\delta}$ ($\bar{\delta}^*$). Totally differentiating (6) we can derive how $\bar{\delta}$ has to be adjusted following changes in $\bar{\tau}$ so that α remains fixed at $\bar{\alpha}$, namely

$$\frac{d\bar{\delta}}{d\bar{\tau}} = \frac{1-\bar{\delta}}{\bar{\tau}(1-\bar{\tau})} < 0, \quad (12)$$

where it should be noted that, since $\bar{\alpha} < 1$, we have $\bar{\delta} > 1$ for $\bar{\tau} > 0$ and $\bar{\delta} < 1$ for $\bar{\tau} < 0$. Similarly for F we obtain $\frac{d\bar{\delta}^*}{d\bar{\tau}^*} < 0$. That is, an increase in the tax rate has to be accompanied by a reduction in the depreciation allowance to hold the $EMTR$ fixed at the optimal level.

4 Comparative Statics

Next, we investigate the properties of the Nash equilibrium. It is straightforward to obtain analytical solutions for $\bar{\tau}(c, n, s)$ and $\bar{\tau}^*(c, n, s)$, and to compute the partial derivatives of taxes and depreciation allowances with respect to c, n and s. But the expressions are complicated. To derive precise results and develop intuition for the comparative static properties of the Nash equilibrium we therefore evaluate the partial derivatives at $s = 0$ (free trade); all proofs are in the Appendix.[8]

Consider how the equilibrium policies change with the trade cost. We can prove:

Proposition 1 *If s is sufficiently small, a marginal increase in the trade cost raises each country's tax rate and decreases the depreciation allowance.*

An increase in s makes country H a more attractive location for the multinationals relative to F. This allows H to raise its tax rate for any given value of its rival's tax rate. In other words, H's best response function, (10), shifts outward. How F's equilibrium tax rate changes with s can be derived from (11). There are two opposing effects. First, an increase in s raises the consumer surplus when a multinational locates in F relative to when it locates in H, which implies that F would ceteris paribus be willing to lower its tax rate to attract the firm. Second, an increase in s lowers the profit the firm can earn when locating in F; hence attracting the firm is only advantageous for F if it can levy a higher tax rate.

The second effect dominates at $s = 0$ (and $s > 0$ if n is sufficiently big) so that both H's and F's equilibrium tax rates are increasing in s. Market integration in the form of a marginal reduction in trade costs between the two

[8]We also ran simulations to verify that the signs of the partial derivatives are robust for $s > 0$.

countries thus leads to lower tax rates. As tax rates decrease, depreciation allowances have to increase to keep the effective marginal tax rate unchanged, so as not to distort the output choices of firms.

Since a rise in the trade cost increases the attractiveness of country H as a plant location relatively to country F, tax rates in H and F diverge as H raises its tax rate by more than F ($\frac{\partial(\bar{\tau}-\bar{\tau}^*)}{\partial s} > 0$). Depreciation allowances, on the other hand, converge so as to keep the $EMTR$ in each country fixed ($\frac{\partial(\bar{\delta}-\bar{\delta}^*)}{\partial s} < 0$). This implies:

Proposition 2 *If s is sufficiently small, a marginal increase in the trade cost leads to a divergence of tax rates and a convergence of depreciation allowances.*

Next, consider the comparative statics with respect to country size n. We can prove the following proposition:

Proposition 3 *If s is sufficiently small and n is sufficiently big, an increase in the size of country H relative to that of F, (i) raises the tax rate in H and reduces the tax rate in F; and (ii) raises the depreciation allowance in H, and reduces the depreciation allowance in F.*

An increase in the size of country H relative to F increases the location rent that H can extract from the multinational through its tax rate, and worsens F's competitive position. Ceteris paribus, this allows H to raise its tax rate and forces F to reduce its tax rate. Changes in n also affect the optimal $EMTR$. Specifically, we obtain $\frac{\partial(\alpha^*-1)}{\partial n} = -\frac{2(1-c)}{c(n+2)^2} < 0$ and $\frac{\partial(\bar{\alpha}^*-1)}{\partial n} = \frac{2(1-c)}{c(2n+1)^2} > 0$. Having a bigger market lowers H's optimal $EMTR$, and vice versa for F whose market shrinks. Changes in equilibrium tax rates and depreciation allowances thus reflect both the changes in location rents and the changes in the optimal $EMTR$.

Finally consider how the equilibrium policies react to changes in the marginal cost:

Proposition 4 *When s is sufficiently small and n is sufficiently big, or when countries are symmetric ($n = 1$) and s and c are sufficiently small, an increase in the marginal cost weakly reduces tax rates and decreases the depreciation allowance.*

An increase in c induces both countries to raise their $EMTR$, as $\frac{\partial(\alpha^*-1)}{\partial c} = \frac{n}{c^2(n+2)} > 0$ and $\frac{\partial(\bar{\alpha}^*-1)}{\partial c} = \frac{1}{c^2(2n+1)} > 0$. An increase in c also reduces the profitability of both investment locations and hence forces countries to lower their tax rates.

5 Empirical Analysis

5.1 Testable Hypotheses

The theoretical model yields two sets of testable hypotheses: (i) ones concerning the slope of policy reaction functions; and (ii) ones concerning the effects of changes in the exogenous variables on equilibrium policies. The hypotheses concerning the strategic relationship between H's and F's policy variables follow directly from the fact that tax rates are strategic complements, and that in each country the depreciation allowance has to move in the opposite direction from the tax rate to keep the country's $EMTR$ at the optimal level. Hence if a rival lowers its tax rate or raises its depreciation allowance, thereby increasing the multinational's profit from locating there, the country will react by lowering its own tax rate and raising its depreciation allowance. This leads to the following testable hypotheses:

Hypothesis 1 The tax rate is a strategic complement to the rival's tax rate.

Hypothesis 2 The tax rate is a strategic substitute to the rival's depreciation allowance, and the depreciation allowance is a strategic substitute to the rival's tax rate.

Hypothesis 3 The depreciation allowance is a strategic complement to the rival's depreciation allowance.

The hypotheses regarding the impact of exogenous variables on equilibrium policies follow from Propositions 1 to 4. These propositions can be straightforwardly translated into testable hypotheses with the caveat that we cannot explicitly test the conditions under which the theoretical predictions hold:

Hypothesis 4 A marginal increase in the trade cost raises the tax rate and decreases the depreciation allowance.

Hypothesis 5 A marginal increase in the trade cost leads to a divergence of tax rates and a convergence of depreciation allowances.

Hypothesis 6 An increase in country size raises the tax rate and the depreciation allowance.

Hypothesis 7 An increase in the marginal cost weakly reduces the tax rates and decreases the depreciation allowance.

5.2 Empirical Specification

The theoretical model suggests that governments may use two instruments to compete for multinational plant location: statutory tax rates and depreciation allowances. The empirical data-set allows inference from panel data. Therefore, we use a time (year) index $t = 1, ..., T$ to refer to a cross-section of countries in a specific period. Let us collect the determinants of the (Nash) equilibrium in these two instruments for year t into the $N \times K$ matrix $\mathbf{X}_t$, where N denotes the number of countries in the sample. According to the theoretical model, country size (n), production cost (c), and trade cost (s) belong in $\mathbf{X}_t$. We refer to the corresponding $N \times 1$ vectors for all countries in year t as $\mathbf{n}_t$, $\mathbf{c}_t$.and $\mathbf{s}_t$, respectively. With panel data, we are able to control for an exhaustive set of time-invariant determinants by accounting for fixed country-specific effects. With matrix notation, for year t this involves an $N \times N$ identity matrix $\mathbf{I}_t$. With these definitions at hand, we may define $\mathbf{X}_t = [\mathbf{n}_t, \mathbf{c}_t, \mathbf{s}_t, \mathbf{I}_t]$ so that $K = 3 + N$. Note that the variables in $\mathbf{X}_t$ matter for the Nash equilibrium in both the $N \times 1$ vector of statutory tax rates τ_t and the vector of depreciation allowance parameters δ_t. However, the marginal effects of these variables (hence, the corresponding parameters in the econometric model) may differ. Let us refer to the $K \times 1$ vector of parameters on $\mathbf{X}_t$ in the equation for statutory tax rates as $\boldsymbol{\xi}_\tau$ and to the one in the equation for depreciation allowances as $\boldsymbol{\xi}_\delta$.

Most importantly, strategic interaction among governments leads to interdependence in the setting of the two instruments according to the theoretical model. The empirical modeling of the corresponding strategic interaction faces two challenges: the domestic statutory tax rate (τ_t) is a function of the foreign statutory tax rate ($\boldsymbol{\tau}_t^*$) and the foreign depreciation allowance parameter ($\boldsymbol{\delta}_t^*$). Similarly, the domestic depreciation allowance parameter (δ_t) is a function of $\boldsymbol{\tau}_t^*$ and $\boldsymbol{\delta}_t^*$. Of course, with a data-set of more than two countries, for each economy $\boldsymbol{\tau}_t^*$ and $\boldsymbol{\delta}_t^*$ reflect weighted averages of the tax parameters of all other countries. Let us define an $N \times N$ weighting matrix $\mathbf{W}$ whose elements correspond to weights.[9]

Two important properties of $\mathbf{W}$ are that it contains zero diagonal elements and that its row sums are bounded, e.g., due to normalizing entries by their row-sum. Hence, domestic tax instruments are (strategically) related to average foreign ones. For instance, for country i the corresponding weighted average of foreign statutory tax rates in year t would be $\tau_{it} = \mathbf{w}_i \tau_t$, where $\mathbf{w}_i$ is a $1 \times N$ row vector of $\mathbf{W}$ whose elements sum up to unity. For all countries, we may write $\boldsymbol{\tau}_t^* = \mathbf{W}\tau_t$. Similarly, we may write $\boldsymbol{\delta}_t^* = \mathbf{W}\delta_t$.

[9] We use three alternative weighting schemes in our analysis. One is based on 'natural' (i.e., predicted) bilateral trade flows (see the Appendix for details). This captures the idea that countries with stronger trade relations are also stronger competitors in tax space. We use predicted rather than actual trade weights to avoid endogeneity of trade flows to profit taxation. Alternatively, we base weights on inverse distance. The latter is most frequently used in empirical models of tax competition and captures the idea that adjacent countries are stronger competitors than others. However, unlike 'natural' trade weights, inverse-distance-based weights ignore country size as a crucial factor in the equation (small countries with low tax rates may be less serious competitors than large countries with low tax rates). And, as a third variant, we use 'natural' stocks of foreign direct investment. There, the notion is that countries with a strong dependence in foreign direct investments are stronger competitors than others.

Let us refer to the slope parameters of the reaction function (with two instruments, we should refer to this as a surface) of τ_t with respect to $\boldsymbol{\tau}_t^*$ as β_τ and to the one of δ_t with respect to $\boldsymbol{\delta}_t^*$ as β_δ. Furthermore, let us denote the slope parameter of the reaction function of τ_t with respect to $\boldsymbol{\delta}_t^*$ as γ_τ and the one of the reaction function of δ_t with respect to $\boldsymbol{\tau}_t^*$ as γ_δ. Then the econometric model capturing profit tax competition in both τ_t and δ_t may be written as

$$\boldsymbol{\tau}_t = \beta_\tau \mathbf{W}\boldsymbol{\tau}_t + \gamma_\tau \mathbf{W}\boldsymbol{\delta}_t + \mathbf{X}_t\xi_\tau + \mathbf{u}_{\tau,t} \tag{13}$$

$$\boldsymbol{\delta}_t = \beta_\delta \mathbf{W}\boldsymbol{\delta}_t + \gamma_\delta \mathbf{W}\boldsymbol{\tau}_t + \mathbf{X}_t\xi_\delta + \mathbf{u}_{\delta,t}. \tag{14}$$

Our theoretical model predicts the signs of the coefficients. According to Hypothesis 1, domestic and foreign statutory tax rates are strategic complements so that $\beta_\tau > 0$. Similarly, domestic and foreign depreciation allowances should be strategic complements by Hypothesis 3 so that $\beta_\delta > 0$. Moreover, Hypothesis 2 states that the domestic statutory tax rate is a strategic substitute to the foreign depreciation allowance, and that the domestic depreciation allowance is a strategic substitute to the foreign tax rate so that $\gamma_\tau < 0$ and $\gamma_\delta < 0$. For the parameters of the country size variable, we expect $\xi_{1,\tau} > 0$ and $\xi_{1,\delta} > 0$ by Hypothesis 6. Regarding the parameters of the cost variable we expect $\xi_{2,\tau} < 0$ and $\xi_{2,\delta} < 0$, respectively by Hypothesis 7. Finally, for the parameters of the trade cost variable, we expect $\xi_{3,\tau} > 0$ and $\xi_{3,\delta} < 0$, according to Hypothesis 4.

5.3 Data and Methodology

We examine these hypotheses using an unbalanced panel data-set of 43 European and also non-European economies which covers the period 1982-2005.[10] The mean statutory corporate tax rates and depreciation allowances

[10] Note that we treat this data-set as a complete panel even though some of the countries (namely the Central and Eastern European ones) are not included before the fall of the iron curtain. From the perspective of tax competition, the rising cross-section over time entails a very specific kind of unbalancedness. Specifically, the opening of the borders to both goods transaction as well as capital flows was equivalent to an increase in the 'size

across all countries and years amount to almost 35 percent and nearly 44 percent, respectively. The corresponding standard deviation for either variable is around 10 percentage points.

Country size is approximated by the logarithm of a country's real GDP (using the year 2000 as the base year) and cost by the logarithm of GDP per capita. GDP and GDP per capita are taken from the World Bank's World Development Indicators 2008. Finally, we approximate a country's trade cost by a trade barrier index which is annually published by the World Economic Forum.[11] Descriptive statistics for all these variables are provided in Table A1 of the Appendix.

Cross-sectional interdependence through the inclusion of $\mathbf{W}\tau_t$ and $\mathbf{W}\delta_t$ in (13) and (14) renders the least squares dummy variable estimator of the parameters (i.e., OLS with fixed country effects) inconsistent. This can be avoided by instrumental variable two-stage least squares (IV-2SLS) with instruments $\mathbf{WX}_t$, $\mathbf{W}^2\mathbf{X}_t$, $\mathbf{W}^3\mathbf{X}_t$, etc. (see Kelejian and Prucha, 1999). If the instruments are relevant and uncorrelated with the disturbances, IV-2SLS will be consistent. In estimation, one should allow the disturbances to be heteroskedastic and cross-sectionally and/or serially correlated $\mathbf{u}_{\tau,t}$ or $\mathbf{u}_{\delta,t}$. This can be accomplished by correcting the estimate of the variance-covariance matrix. We do so by employing a version of the variance-covariance matrix estimator for spatially and/or serially correlated data following Driscoll and Kraay (1998). As our data-set covers 24 consecutive periods, this estimator yields, under the adopted assumptions, consistent parameter estimates for the covariates and fairly good estimates also of the fixed effects and, hence, the disturbances $\mathbf{u}_{\tau,t}$ and $\mathbf{u}_{\delta,t}$.[12] See the Appendix for further information

of the world' in terms of the number of politically independent and at least partially integrated economies and hence of the number of relevant competitors for FDI.

[11] For instance, this index has been employed as a measure of trade cost in Carr, Markusen, and Maskus (2001) and Markusen and Maskus (2002). We are grateful to Keith Maskus for providing the data.

[12] With a very small number of periods but a large number of countries N, it would not be possible to obtain valid estimates of these residuals due to the relatively large number of fixed country effects.

about the estimator used.

5.4 Results

Before turning to regression analysis, let us consider simple correlations between domestic and foreign tax instruments for the average country and year in the sample. We do so in Table 1 by using 'natural' bilateral trade flows as weights for foreign tax instruments; see the Appendix for a definition of these weights. We consider simultaneous correlations at time t but also correlations between domestic tax instruments at t and foreign tax instruments in periods $t-2$, $t-3$, and $t-5$. The results are summarized in Table 1.

−− Table 1 −−

Of course, the corresponding correlation coefficients may be biased for two reasons: first, domestic and foreign tax instruments are endogenous to each other, at least contemporaneously (see the previous subsection); and, second, omitting market size, production costs, trade costs, and a number of time-invariant variables precludes an interpretation of these correlation coefficients as slopes of the reaction function.

However, the numbers in Table 1 suggest that the cross-sectional variation in the data is relatively important. This can be seen from the fact that the correlation coefficients between domestic tax instruments in t and weighted foreign tax instruments for up to a five-year lag are very similar. This calls for the use of fixed effects in the econometric models. However, the correlation coefficients between contemporaneous domestic and weighted foreign instruments are highest, suggesting that this should be the most important relationship to look at in the regression analysis.

In what follows, we summarize IV-2SLS parameter estimates in the benchmark models for statutory tax rates and depreciation allowances. With each of the models, we report two sets of standard errors: ones that are based on the Huber-White sandwich estimator of the variance-covariance matrix (ignoring any spatial or serial correlation) and ones that are based on the SHAC estimator (considering serial correlation of the disturbances with their counterparts in up to three periods in the past). Tables 2 and 3 summarize the corresponding estimates for 'natural' bilateral trade and inverse bilateral distance as the weights for foreign tax instruments, respectively.

−− Tables 2-3 −−

Let us briefly describe the general model characteristics before turning to the parameter estimates. First of all, the explanatory power of both the first and the second stage models is generally high (in the table we only report partial R^2s for the first-stage models, but the R^2s in the second stage are even higher). As expected, country-specific characteristics are important and abandoning the country dummies likely would lead to biased parameter estimates for the covariates. Indeed, it turns out that treating third-country tax variables as exogenous would be harmful, given the chosen specification. This points to strategic interaction in tax parameters among governments as hypothesized. Moreover, the incremental explanatory power of the identifying instruments for the third-country averages of the tax variables is relatively high.[13] The latter renders the insignificant over-identification tests meaningful. Overall, we may conclude that the IV-2SLS models work well.

Regarding the covariates determining the Nash equilibrium in tax parameters, we find that larger countries tend to set significantly higher statutory tax rates and significantly higher depreciation allowances. Higher production costs are associated with significantly lower statutory rates and significantly lower depreciation allowances. Higher trade costs lead to significantly higher statutory tax rates but insignificantly lower depreciation allowances. Of the six point estimates for the covariates (i.e., the determinants of the Nash tax rates), none contradicts the theoretical hypotheses. This holds true for both Tables 2 and 3.

The parameters determining the slope of the reaction function in the two dimensions are highly significant throughout. In particular, they indicate that

[13] In matrix notation, we use $\mathbf{WX}$, $\mathbf{W}^2\mathbf{X}$, and $\mathbf{W}^3\mathbf{X}$ as instruments.

domestic and foreign statutory tax rates are strategic complements, while domestic statutory tax rates and foreign depreciation allowances are strategic substitutes. Furthermore, domestic and foreign depreciation allowances are strategic complements while domestic depreciation allowances and foreign statutory tax rates are strategic substitutes. Hence, all the slope parameters of the reaction function are consistent with our theoretical model, irrespective of whether we consider 'natural' trade weights or inverse distance weights to aggregate foreign countries' profit tax instruments.

5.5 Sensitivity Analysis

We assess the sensitivity of our findings in qualitative terms along three general lines: measurement of some of the right-hand-side variables (especially country size, production costs, and trade costs), the aggregation concept for construction of foreign tax instruments (i.e., the spatial weighting scheme), and the possibly different behavior and slopes of reaction functions of countries applying tax exemption versus non-exemption on foreign-earned profits.

In the benchmark models summarized in Table 2, we used log real GDP as a measure of country size. In the theoretical model, we referred to country size as the number of households/workers in the economy. While log GDP might generally be a better measure for aggregate demand, log population size would be closer to our model. However, replacing log GDP by log population size has little influence on the reaction function parameters. This becomes obvious from the set of parameters in the upper block of results reported in Table 4.

−− Table 4 −−

Furthermore, we used GDP per capita as a measure of production costs in the benchmark models. Again there are pros and cons for this choice. The fact that expenditures to cover fixed costs will be accounted for in GDP is among the latter. An alternative measure of production costs would be labor compensation (available from the World Development Indicators 2005). Yet, replacing log GDP per capita by labor compensation renders the results qualitatively unaffected, again (see the second block of results in Table 4).

The trade cost index in the benchmark models relies on a survey among managers and CEOs. Managers might find it difficult to distinguish between sheer trade frictions and obstacles to market transactions as such. Accordingly, the index might reflect other barriers than just trade barriers. We address this concern by using the average cost-insurance-freight to free-on-board bilateral trade values by country (across all importers) and year in logs. Again, the signs of the reaction function parameters are unaffected by this choice (see the third block of results in Table 4).

Concerning the weights to aggregate foreign countries' tax parameters, the results might be sensitive to the use of natural-trade-based weights or inverse distance-based weights. We suggest sensitivity checks along two general lines to infer this issue, namely using alternative weighting concepts such as contiguity weighting (direct neighbors matter with the same weight for tax competition while non-neighbors do not matter at all) and foreign direct investment weighting (tax competition is hypothesized to be tougher among natural foreign direct investment partners). The Appendix provides more detail on the construction of these alternative weighting schemes. The two blocks at the bottom of Table 4 indicate that common borders or higher natural levels of bilateral foreign direct investment are related to tax competition in a similar fashion as natural trade flows or inverse geographical distances. In qualitative terms, the results for the signs of the slope parameters of the reaction function are unaffected by these alternative choices of the weighting scheme.

Finally, one might conjecture that countries applying a tax exemption scheme to double taxation relief of foreign-earned profits would behave in the way described here while countries applying a tax credit system (such as the United States) or a tax deduction system would not. There are various ways of assessing this issue. We chose to define an indicator variable which is unity for non-exemption countries and zero else. Define the corresponding indicator variable vector for period t as $\mathbf{n}_t$. Then, we included $\mathbf{W}\boldsymbol{\tau}_t$ and $\mathbf{W}\boldsymbol{\delta}_t$ along with the interactive terms $\mathbf{W}\boldsymbol{\tau}_t \circ \mathbf{n}_t$ and $\mathbf{W}\boldsymbol{\delta}_t \circ \mathbf{n}_t$, where $\circ$ indicates element-wise products. We found insignificant point estimates on the latter two variables and significant and quantitatively unaltered ones on the former two variables. Moreover, the findings suggested that the reaction function is insignificantly flatter for non-exemption countries than for exempting ones. Hence, we do not find a starkly different behavior between exempting and non-exempting countries in their competition for the mobile profit tax base.

6 Regional Integration and Tax Policy

In this section we seek to examine the role that regional integration may have played in fostering tax competition and changing tax rates and depreciation allowances in our sample of countries. We do so by comparing the policy changes predicted by our model over the period 1985–2000 with counterfactual scenarios, in which the countries did not become members of regional integration agreements, such as the EU, the European Free Trade Agreement (EFTA), the Canada-US Free Trade Agreement (CUSTA) and the North American Free Trade Agreement (NAFTA).[14]

In Table 2 we used 'natural' trade weights to aggregate foreign tax parameters. Notice that regional trade agreements affect the elements of $\mathbf{W}$, according to Table A2 in the last subsection of the Appendix. According to that table, trade flows between any pair of countries in a regional trade agreement are about 72 percent larger than otherwise – certainly a long-run effect of trade regionalism, since it is based on a cross-sectional sample in Table A2. Second, regional trade agreements affect the trade cost index as a Nash equilibrium shifting variable used in Tables 2-4. It turns out that, on average, participation of a country in a regional trade agreement in the

[14] In this section, we aim at studying the consequences of discrete and fairly drastic changes in regional integration on tax policy. Our propositions and the corresponding hypotheses are derived locally and thus only valid in the neighborhood of certain parameter configurations. However, simulations suggest that our findings also hold for discrete changes in the parameters.

model reduces the trade cost index by -3.400 units. The latter is obtained from a regression of the index on free-trade-area membership in a panel of all *country-pairs* of the 43 economies and years 1982-2000. The corresponding direct effect of regional integration on tax parameters is then -3.400 times the corresponding coefficients in Table 2. However, this effect is modified through tax competition and becomes heterogeneous depending on the row characteristics of normalized 'natural' trade weights $\mathbf{W}$, as will become clear below.

Let us refer to the (complete or partial) absence of membership in a regional trade agreement in Europe or North America as an unobserved counterfactual in later years of the panel. Let us use superscript c to denote counterfactual values of the explanatory variables, $\mathbf{X}_t^c$, or the weighting matrix, $\mathbf{W}^c$. Then, the typical elements of $\mathbf{X}_t^c\xi_\tau$ and $\mathbf{X}_t^c\xi_\delta$ due to less integration in trade are always higher than their counterparts in $\mathbf{X}_t\xi_\tau$ and $\mathbf{X}_t\xi_\delta$ as used in (13) and (14), respectively. The elements upon which $\mathbf{W}^c$ is based are lower than or equal to their counterparts used in $\mathbf{W}$ (before normalization). Obviously, the nonlinearity of (13) and (14) does not permit a trivial inference of the consequences of such changes on predicted Nash tax rates. The ultimate impact will be determined by

$$\Delta\boldsymbol{\tau}_t \equiv \widehat{\boldsymbol{\tau}}_t - \widehat{\boldsymbol{\tau}}_t^c, \Delta\boldsymbol{\delta}_t \equiv \widehat{\boldsymbol{\delta}}_t - \widehat{\boldsymbol{\delta}}_t^c, \tag{15}$$

where Δ is the difference operator, '$\wedge$' denotes estimates, and where

$$\widehat{\boldsymbol{\tau}}_t = (\mathbf{I} - \hat{\beta}_\tau\mathbf{W} - \hat{\gamma}_\tau\mathbf{W}[\mathbf{I} - \hat{\beta}_\delta\mathbf{W}]^{-1}\mathbf{W})^{-1}\mathbf{X}_t, \tag{16}$$

$$\widehat{\boldsymbol{\delta}}_t = (\mathbf{I} - \hat{\beta}_\delta\mathbf{W} - \hat{\gamma}_\delta\mathbf{W}[\mathbf{I} - \hat{\beta}_\tau\mathbf{W}]^{-1}\mathbf{W})^{-1}\mathbf{X}_t, \tag{17}$$

$$\widehat{\boldsymbol{\tau}}_t^c = (\mathbf{I} - \hat{\beta}_\tau\mathbf{W}^c - \hat{\gamma}_\tau\mathbf{W}^c[\mathbf{I} - \hat{\beta}_\delta\mathbf{W}^c]^{-1}\mathbf{W}^c)^{-1}\mathbf{X}_t^c, \tag{18}$$

$$\widehat{\boldsymbol{\delta}}_t^c = (\mathbf{I} - \hat{\beta}_\delta\mathbf{W}^c - \hat{\gamma}_\delta\mathbf{W}^c[\mathbf{I} - \hat{\beta}_\tau\mathbf{W}^c]^{-1}\mathbf{W}^c)^{-1}\mathbf{X}_t^c. \tag{19}$$

-- Table 5 --

We summarize the consequences of two counterfactual scenarios in Table 5. There we report the average actual change in tax parameters over the sample period at the top, the predicted change according to our model (which is somewhat smaller than the actual change),[15] and the following two counterfactual changes: one where we ignore any integration through regional free-trade trade agreements (FTAs) after 1981,[16] and one where we ignore any regional FTAs before or after 1981.[17] In the table, we focus on changes between 1982 and 2000. Since only 18 countries are covered in 1982, all changes refer to averages for those economies. According to the results in the table, the model predicts a smaller reduction in tax rates and a somewhat higher increase in depreciation allowances in the no/less integration counterfactual scenarios than in the benchmark equilibrium. Specifically, the predicted average change in corporate tax rates is more than 15% higher than the average change in the counterfactual scenario without any FTA integration. This is consistent with the view that regional trade integration contributes significantly to tougher tax competition. As for the change in depreciation allowances we find that in the benchmark scenario the rise in the average depreciation allowance is 26% smaller on average than in the counterfactual scenario without any FTAs. Our theoretical model suggests that integration, ceteris paribus, should have accelerated the rise in depreciation allowances. However, since in the data we cannot isolate the effects of changes in integration from the impact of changes in other fundamental drivers of the tax base, this finding does not contradict the theoretical hypotheses.

Due to the nonlinear model structure, it is impossible to orthogonally decompose the role of the changing reaction function (through the difference between $\mathbf{W}$ and $\mathbf{W}^c$) versus the changing Nash shifters (through the difference between $\mathbf{X}_t$ and $\mathbf{X}_t^c$). However, we may obtain tentative insights into their relative importance for the outcome by calculating predicted changes when using $\mathbf{W}^c$ together with $\mathbf{X}_t$ in (18) and (19), and, alternatively, when

[15] Notice that the econometric model is estimated in levels and, hence, performs somewhat better in predicting average tax parameter levels than changes in tax parameters.

[16] Important changes in economic integration in our sample after 1981 were the enlargements of the EU (in 1986, 1995, and 2004), the corresponding changes in EFTA, as well as CUSTA and NAFTA.

[17] In the latter scenario there is hence no EU, no EFTA, no CUSTA and no NAFTA.

using $\mathbf{W}$ together with $\mathbf{X}_t^c$ rather than using $\mathbf{W}^c$ with $\mathbf{X}_t^c$. According to the results in Table 5, the change in equilibrium corporate tax rates between 1982 and 2000 would have been even larger in the absence of a change in $\mathbf{W}^c$.[18] Hence, the adjustment of the (slope of the) reaction function offsets part of the competitive pressure on tax rates through regional integration. All of those effects are somewhat stronger when abolishing all free trade agreements in the counterfactual scenario rather than only the ones concluded after 1981.

While Table 5 focused on the first moment of changes in tax parameters due to economic integration in Europe and North America, we may also consider the consequences of economic integration for the (normalized) second moment, asking whether economic integration fostered a divergence or a convergence of tax parameters. According to our theoretical model, regional integration – by exerting competitive pressure on individual countries' profit tax policy – should lead to a convergence of tax rates across countries and a divergence of depreciation allowances. To shed light on that matter, we summarize in Table 6 changes in the coefficient of variation of the policy scenarios of Table 5.

−− Table 6 −−

According to the results at the top of Table 6, the model prediction about the change in tax parameters between 1982 and 2000 for the 18 considered economies is one of convergence. Quite clearly, the results suggest that abolishing regional integration completely or keeping it at its 1981 level leads to a divergence of the predicted tax parameters. Hence, from that exercise one could conclude that if harmonization of profit tax policy is on the political agenda, integration of trade itself has contributed to such a harmonization through the trade regionalism in the developed part of the world over the last couple of decades.

[18] Notice that the change from $\mathbf{W}$ to $\mathbf{W}^c$ implies a different weighting of foreign countries' tax rates for both an individual as well as the average economy.

7 Conclusions

This paper examined international tax competition in two tax instruments: a profit tax rate and a depreciation allowance that determines the tax base. In our theoretical model, we explored the reaction functions in these two dimensions and investigated how the equilibrium is affected by marginal, alternative changes in three fundamentals: country size, production costs, and trade costs. This yielded testable hypotheses concerning the slope of policy reaction functions and changes in equilibrium policies.

In the empirical part of the paper, we tested these hypotheses with a panel data-set of 43 countries over the period 1982–2005 and found that the regression coefficients characterizing both the slopes of the reaction function and fundamental shifters of equilibrium tax rates were generally significant and had the predicted sign. In particular, we showed that the domestic statutory tax rate is a strategic complement to foreign statutory tax rates and a strategic substitute to foreign depreciation allowances. The domestic depreciation allowance was shown to be a strategic substitute to foreign statutory tax rates and a strategic complement to foreign depreciation allowances. Moreover, we found tax rates to be increasing and depreciation allowances to be decreasing in intra-regional trade costs. Country size had a positive and production costs a negative effect on both tax rates and depreciation allowances.

We then used the empirical model to simulate the effects of regional integration on tax rates and depreciation allowances. In particular, we computed counterfactual scenarios, in which the countries in our sample did not participate in regional integration agreements, such as the EU or NAFTA. We compared predicted equilibrium tax rates based on 'natural' trade weights cum regional trade agreements with ones based on counterfactual 'natural' trade weights in the absence of such agreements. The picture that emerged was that changes in corporate tax systems are by and large consistent with regional integration. Regarding the corporate tax rates we found that the predicted average change in corporate tax rates was more than 15% higher than the average change in the counterfactual scenario without any regional trade integration. This is consistent with the view that regional trade integration has contributed significantly to tougher tax competition and to a fall in corporate tax rates.

8 Appendix

8.1 Proofs

8.1.1 Proof of Lemma 1

We derive the $EMTR$ for H; the derivation of F's $EMTR$ is equivalent. The after-tax profit generated by a firm located in H and selling its output in both H and F is given by (7). The profit-maximizing output choices are

$$Q_H = \frac{n(1-\alpha c)}{2}, \text{ and } Q_F = \frac{(1-\alpha c - s)}{2},$$

which implies a maximized after-tax profit equal to:

$$\hat{\Pi}_H = (1-\tau)\frac{n(1-\alpha c)^2 + (1-\alpha c - s)^2}{4}. \tag{20}$$

The tax revenue accruing to H from such a firm is equal to:

$$\tau\frac{n(1-\alpha c)^2 + (1-\alpha c - s)^2}{4} - \frac{(1-\alpha)c\,(n(1-\alpha c) + (1-\alpha c - s))}{2}, \tag{21}$$

where the second term adjusts for the fact that for $\alpha \neq 1$ there is an implicit subsidy/tax on the firm's output.

Now it is straightforward to compute the social welfare country H derives from the presence of domestic and multinational firms. In the case of domestic firms, the profit tax is simply redistributed to the local owners and thus does not affect welfare. The welfare associated with a good produced by a domestic firm is hence independent of τ and thus equal to the sum of consumer surplus (the first term) and profit adjusted for the implicit tax/subsidy (the last two terms):

$$W_H(\alpha) = \frac{n(1-\alpha c)^2}{8} + \frac{n(1-\alpha c)^2 + (1-\alpha c - s)^2}{4} - \frac{(1-\alpha)c\,(n(1-\alpha c) + (1-\alpha c - s))}{2}.$$

In the case of a good produced by a multinational, social welfare equals the sum of consumer surplus and tax revenue:

$$W_H(\alpha,\tau) = \frac{n\left(1-\alpha c\right)^2}{8} + \tau\frac{n\left(1-\alpha c\right)^2 + \left(1-\alpha c - s\right)^2}{4} - \frac{(1-\alpha)c\left(n\left(1-\alpha c\right) + \left(1-\alpha c - s\right)\right)}{2}.$$

In setting τ the government has to take into account the multinational's participation constraint (8). Since this constraint has to be binding at the optimum, we can use it to eliminate τ in the welfare function. This yields as social welfare:

$$W_H(\alpha) - \left(1-\tau^*\right)\frac{\left(1-\alpha^* c\right)^2 + n\left(1-\alpha^* c - s\right)^2}{4}. \tag{22}$$

Hence the optimal α, denoted by $\bar{\alpha}$, is the same for domestic and multinational firms. Maximization of $W_H(\alpha)$ with respect to α gives:

$$\bar{\alpha} = \frac{\left(2c - n + 2cn\right)}{\left(n+2\right)c}. \tag{23}$$

8.1.2 Proof of Proposition 1

It is straightforward to show that at $s = 0$ and for n sufficiently big:

$$\begin{aligned}
\frac{\partial\bar{\tau}}{\partial s} &= \frac{1}{2}\frac{\left(2n^2 - 3n + 2n^3 - 4\right)\left(n+2\right)}{\left(1-c\right)\left(n+1\right)^3\left(2n+1\right)} > 0,\\
\frac{\partial\bar{\tau}^*}{\partial s} &= \frac{1}{2}\frac{\left(2n+1\right)^2\left(n^2 - 2n - 2\right)}{\left(1-c\right)\left(n+1\right)^3\left(n+2\right)^2} > 0,\\
\frac{\partial\bar{\delta}}{\partial s} &= \left(-2\right)\frac{\left(2n^2 - 3n + 2n^3 - 4\right)\left(2n+1\right)n}{\left(4n + 3n^2 - 1\right)^2\left(n+1\right)c} < 0,\\
\frac{\partial\bar{\delta}^*}{\partial s} &= \left(-2\right)\frac{\left(n+2\right)^2\left(n^2 - 2n - 2\right)\left(2n+1\right)}{\left(8n + 5n^2 + 5\right)^2\left(n+1\right)c} < 0.
\end{aligned}$$

8.1.3 Proof of Proposition 2

At $s = 0$ we obtain

$$\begin{aligned}
\frac{\partial(\bar{\tau} - \bar{\tau}^*)}{\partial s} &= \frac{(58n + 39n^2 + 6n^3 + 2n^4 + 30)(n-1)}{2(1-c)(n+1)^2(n+2)^2(2n+1)} > 0, \\
\frac{\partial(\bar{\delta} - \bar{\delta}^*)}{\partial s} &= \frac{(-2)(2n+1)(n-1)Z}{(8n + 5n^2 + 5)^2(4n + 3n^2 - 1)^2 c} < 0, \\
\text{where} \quad Z &\equiv \left(148n + 429n^2 + 492n^3 + 350n^4 + 168n^5 + 41n^6 - 8\right)
\end{aligned}$$

8.1.4 Proof of Proposition 3

At $s = 0$ and assuming that n is sufficiently big, we obtain the following signs for the derivatives:

$$\begin{aligned}
\frac{\partial\bar{\tau}}{\partial n} &= \frac{1}{2}\frac{(10n + n^2 + 7)}{(2n+1)^2(n+1)^2} > 0, \\
\frac{\partial\bar{\tau}^*}{\partial n} &= \left(-\frac{1}{2}\right)\frac{(3n + 6n^2 + 5n^3 + 4)}{(n+2)^3(n+1)^2} < 0, \\
\frac{\partial\bar{\delta}}{\partial n} &= 2\frac{(1-c)(2n^4 - 11n^2 - 2n^3 - 4n - 3)}{(4n + 3n^2 - 1)^2(n+2)^2 c} > 0, \\
\frac{\partial\bar{\delta}^*}{\partial n} &= (-2)\frac{(1-c)(10n + n^2 + 7)}{(8n + 5n^2 + 5)^2 c} < 0.
\end{aligned}$$

8.1.5 Proof of Proposition 4

For $s = 0$ and n sufficiently big, we obtain $\frac{\partial\bar{\tau}}{\partial c} = 0$, $\frac{\partial\bar{\tau}^*}{\partial c} = 0$, and

$$\begin{aligned}
\frac{\partial\bar{\delta}}{\partial c} &= -\frac{(2n + n^2 + 3)n}{(3n^2 + 4n - 1)(n+2)c^2} < 0 \\
\frac{\partial\bar{\delta}^*}{\partial c} &= -\frac{(2n + n^2 + 3)}{(8n + 5n^2 + 5)c^2} < 0.
\end{aligned}$$

For $n = 1$ (symmetric countries) and $s > 0$, we find that

$$\frac{\partial\bar{\tau}}{\partial c} = \frac{(-6)\left(32(1-c)^2 - 9s^2\right)s}{(24cs - 24s - 64c + 32c^2 + 9s^2 + 32)^2} < 0 \text{ for } s \text{ close to zero,}$$

and

$$\frac{\partial\bar{\delta}}{\partial c} = \left(-\frac{1}{3}\right)\frac{K}{(8 - 8c - 3s)^2(4 - 4c - 3s)^2 c^2} < 0,$$

for s can c small enough, where

$$\begin{aligned} K &= 3840cs - 1536s - 4096c + 6144c^2 - 4096c^3 + 1024c^4 + 1008s^2 \\ &\quad -432s^3 + 81s^4 - 2016cs^2 - 2304c^2s + 648cs^3 - 768c^3s + 768c^4s \\ &\quad +1008c^2s^2 - 216c^2s^3 + 1024 \end{aligned}$$

8.2 Data sources

The data used in the present analysis fall into three categories: ones on statutory corporate tax rates and depreciation allowances (the dependent variables of our empirical analysis); explanatory variables which are supposed to measure country size (n), production costs (c), and trade costs (s) in the theoretical analysis; and variables which measure the relative independence of tax parameters across countries as a function not only of unilateral n, c, and s, but also of bilateral integration among the economies – we will use 'natural' bilateral trade flows and, in the sensitivity analysis, stocks of bilateral foreign direct investment as measures thereof. Let us summarize in this subsection of the appendix which variables we use and which sources they come from.

Information on tax codes are primarily taken from the following online sources of the International Bureau of Fiscal Documentation (IBFD): Asia-Pacific - Taxation & Investment; Central/Eastern Europe - Taxation & Investment; Corporate Taxation in Europe; Global Tax Surveys; and Tax News Service.

Additionally, the information on tax law from a number of printed publications has been used:

- Arthur Anderson, 1992-1996. *A tax guide to Europe*, London: Arthur Andersen

- Baker&McKenzie, 1999. *Survey of the effective tax burden in the European Union*, Amsterdam.

- Commission of the European Communities, 1992. *Report of the committee of independent experts on company taxation*, Brussels and Luxembourg.
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- Coopers & Lybrand, 1991-1998. *International tax summaries : a guide for planning and decisions*, Chichester: John Wiley & Sons.
- Ernst&Young, 2003. *Company taxation in the new EU Member states survey of the tax regimes and effective tax burdens for multinational investors*, Frankfurt am Main.
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- IBFD, 1994-1999. *Central and East European Tax Directory*, Amsterdam.
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These sources provide information about the number of years for which depreciations can be claimed (i.e., the 'depreciation rate'), the depreciation system (i.e., whether there depreciation follows a straight line or a declining balance schedule), and on (general) investment incentives (e.g., on the existence of extra first-year allowances in Australia, Poland, or Spain). Otherwise, the computation of the net present value of depreciation allowances follows King and Fullerton (1984) and Devereux and Griffith (1998). In line with those authors, we use the most generous option of depreciation in case that the model firm has several opportunities to choose from. The data used here are a (balanced) subset of the ones in Egger, Loretz, Pfaffermayr, and Winner (2009).

Measures of Nash-equilibrium-shifting variables n, c, and s:

In Tables 2-4, we associate country size (n) mainly with log real GDP, production costs (c) mainly with log GDP-per-capita, and trade costs (s) mainly with a trade cost index. For instance, this is the case throughout Tables 2-3. The source of the data on real GDP and GDP per capita is the World Bank's World Development Indicators 2008. The trade cost index is published by the World Economic Forum and has kindly been provided by Keith Maskus.

In the sensitivity analysis (Table 4), we use log population instead of log real GDP as an alternative measure for n, log manufacturing wages per worker instead of log GDP per capita to measure production costs c, and log unilateral cost-insurance-freight/free-on-board (c.i.f./f.o.b.) ratios of goods trade flows as a measure of trade costs (s). These variables are taken from the following sources. Population is based on figures in the World Bank's World Development Indicators. Average wages per worker in manufacturing stem from United Nations Industrial Development Organization's Industrial Statistics Database. To calculate unilateral c.i.f./f.o.b. ratios, we use bilateral aggregate goods trade data from the United Nations' World Trade Database. More specifically, we take all countries' imports from a given economy and divide them by this country's exports into all economies in our sample in a given year. Theoretically, this ratio should be larger than unity and the deviation from unity should measure unilateral trade costs in a given year with the covered countries. It is well known that c.i.f./f.o.b. ratios are not a perfect measure of trade costs, since they are prone to measurement error. However, Limão and Venables (2001) illustrated that they are at least systematically correlated with (for most countries unobserved) true trade costs.

Measures of the strength of interdependence between domestic and foreign tax rates:

In Tables 2-4, we pursue a variety of approaches to weight foreign countries' tax parameters, i.e., to parameterize the channel and the decay of tax competition in some metric. Since economic integration is a key factor determining tax competition in our theoretical analysis, our benchmark results in Table 2 are based upon 'natural' goods-trade-weighted tax parameters. For this, we take bilateral exports among all countries in our sample for the years 1982-2000 from United Nations' World Trade Database. How we then proceed to obtain 'natural' bilateral (export plus import) trade weights is described in the last subsection of this Appendix.

Alternatively, we use inverse bilateral distances between all countries (in Table 3), contiguity-based weights (in Table 4) and 'natural' bilateral stock-of-foreign-direct-investment-based weights (in Table 4). Bilateral distance and a bilateral contiguity indicator is taken from the Geographical Database published by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). Bilateral stocks of outward FDI are taken from the FDI online database of the United Nations Conference on Trade and Development (UNCTAD). As for 'natural' bilateral trade weights, the last subsection of this Appendix describes how we obtain 'natural' bilateral (outward plus inward) FDI stock weights.

8.3 Descriptive statistics

Table A1 summarizes the averages and standard deviations for the key variables in our analysis: statutory corporate tax rates and depreciation allowances as the two endogenous variables and measures of market size (GDP), production costs (GDP/capita), and trade costs.

−− Table A1 −−

Summary statistics on other variables used in the sensitivity analysis in Table 4 are available from the authors upon request.

8.4 IV-2SLS GMM estimator

For the definition of the IV-2SLS GMM estimator and its heteroskedasticity and spatial as well as serial autocorrelation-consistent (SHAC) estimator of the variance-covariance matrix in the spirit of Driscoll and Kraay (1998), it will be useful to introduce some further notation. Recall that we indicate countries by $i = 1, ..., N$ and time periods by $t = 1, ..., T$. For convenience, let us use the running index $\ell = \tau, \delta$ to refer to the two equations (13) and (14), respectively. Furthermore, define the $N \times (K+2)$ matrix $\mathbf{Z}_t = [\mathbf{W}\tau_t, \mathbf{W}\delta_t, \mathbf{X}_t]$ and refer to the $NT \times (K+2)$ stacked version of this matrix (covering all years) as $\mathbf{Z}$. IV-2SLS potentially involves sets of instruments which differ across equations. Define the number of instruments in equation ℓ as $P_\ell \geq K+2$ and collect the instruments for equation ℓ and all years into the $NT \times P_\ell$ matrix $\mathbf{D}_\ell$.[19] Then, we may define the projection $\hat{\mathbf{Z}}_\ell = \mathbf{D}_\ell(\mathbf{D}_\ell'\mathbf{D}_\ell)^{-1}\mathbf{D}_\ell'\mathbf{Z}_\ell$. Later on,

[19] Of course, the $NY \times K$ matrix $\mathbf{X}$ of exogenous variables in (13) and (14) is part of $\mathbf{D}_\ell$.

we will refer to one row of $\hat{\mathbf{Z}}_\ell$ by the $1 \times (K+2)$ vector $\hat{\mathbf{z}}_{\ell it}$. Finally, collect the IV-2SLS parameters for equation ℓ into the $(K+2) \times 1$ vector $\boldsymbol{\theta}_\ell$. Let us refer to the (inefficient) estimate of the $(K+2) \times (K+2)$ variance-covariance matrix of the parameters as $\hat{\mathbf{V}}_\ell = (\mathbf{Z}_\ell' \mathbf{D}_\ell \mathbf{D}_\ell' \mathbf{Z}_\ell)^{-1}$.

Driscoll and Kraay (1998) suggest averaging the moment conditions to obtain $\mathbf{h}_t(\boldsymbol{\theta}_\ell) = \frac{1}{N}\sum_{i=1}^N \mathbf{h}_{it}(\boldsymbol{\theta}_\ell)$. Let us use the notation $\mathbf{h}_{\ell t} = \mathbf{h}_t(\boldsymbol{\theta}_\ell)$ and refer to one row of $\mathbf{D}_\ell$ by $\mathbf{d}_{\ell it}$ to write

$$\mathbf{h}_{\ell t} = \frac{1}{N}\sum_{i=1}^N \mathbf{d}_{\ell it}\mathbf{u}_{\ell it}; \quad \mathbf{h}_{\ell t'} = \frac{1}{N}\sum_{i=1}^N \mathbf{d}_{\ell it'}\mathbf{u}_{\ell it'}. \tag{24}$$

with $t, t' = 1, ..., T$. Furthermore, let us define the matrix

$$\mathbf{S}_{\ell T} = \frac{1}{T}\sum_{t=1}^T \sum_{t'=1}^T E[\mathbf{h}_{\ell t}\mathbf{h}_{\ell t'}'] \tag{25}$$

and note that $E[\mathbf{h}_{\ell t}\mathbf{h}_{\ell t'}'] = \frac{1}{N^2}\sum_{i=1}^N \mathbf{d}_{\ell it}\mathbf{d}_{\ell it'}' E[u_{\ell it}u_{\ell it'}]$.

A HAC estimator of the variance-covariance matrix with IV-2SLS in the spirit of Driscoll and Kraay (1998) is then defined as

$$\hat{\mathbf{V}}_{HHC} = (\mathbf{Z}'\mathbf{D}_\ell \hat{\mathbf{S}}_{\ell T}^{-1} \mathbf{D}_\ell' \mathbf{Z})^{-1}. \tag{26}$$

Driscoll and Kraay (1998) prove that such a Newey and West (1987)-type estimator of the variance-covariance matrix relies on fairly weak assumptions.

8.5 "Natural" trade and foreign direct investment based weights matrices in the empirical model

In Table 2 we use 'natural' trade and in Table 4 'natural' foreign direct investment as weights to compute competitor countries' statutory tax rates and depreciation allowances. They are derived from cross-sectional empirical models using average bilateral exports and stocks of outward foreign direct investment, respectively, as the dependent variable for the period 1982-2000 for all pairings among the 43 countries in our analysis. Apart from exporter (parent country) and importer (host country) fixed effects, the empirical models include the following explanatory variables of exports or outward foreign direct investment: log bilateral distance, common border between exporter and importer, and a free trade area indicator (as reported to the World Trade Organization).

Since both trade flows and stocks of foreign direct investment take zero values, we follow Santos Silva and Tenreyro (2006) and estimate the equations by a Poisson pseudo-maximum-likelihood routine. In Table A2, we summarize the coefficient estimates for the model determining 'natural' bilateral trade flows which are used to weight foreign statutory corporate tax rates and depreciation allowances for each year in Table 2. The associated model predictions are then used to compute predicted ('natural') exports plus imports and outward plus inward stocks of FDI, respectively, for each country pair. This results in two matrices whose elements are divided by the corresponding row sums and diagonal elements are set to zero to obtain a matrix **W** which is used to weight a country's competitors' tax parameters.

−− Table A2 −−

The estimation results for bilateral FDI stocks which are used as an alternative weighting scheme in the sensitivity analysis at the bottom of Table 4 are available form the authors upon request.

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Table 1 - Unconditional correlations between domestic and foreign tax instruments

	Domestic tax instruments (dependent variable) in year t			
	Statutory tax rate		Depreciation allowance	
Foreign tax instrument	Coef.	Std.		
Statutory tax rate in year t	2,394	0,208 ***	-0,674	0,134 ***
Depreciation allowance in year t	-1,522	0,123 ***	0,408	0,072 ***
Statutory tax rate in year t-2	2,368	0,214 ***	-0,601	0,101 ***
Depreciation allowance in year t-2	-1,459	0,133 ***	0,392	0,056 ***
Statutory tax rate in year t-3	2,307	0,220 ***	-0,600	0,112 ***
Depreciation allowance in year t-3	-1,419	0,139 ***	0,406	0,064 ***
Statutory tax rate in year t-5	2,155	0,228 ***	-0,669	0,116 ***
Depreciation allowance in year t-5	-1,406	0,149 ***	0,457	0,072 ***

Notes: 43 countries over the period 1982-2000. Third-country weights are based on potential (predicted) bilateral goods trade flows. All regressions include country fixed effects but no other covariates. Standard errors are robust to heteroskedasticity and serial correlation. Correlations should not be interpreted as reaction function parameters, since lacking fundamentals lead to inconsistent Nash tax rates.

Table 2 - Reaction function estimation for coporate tax rates and depreciation allowances (potential-trade-based third-country weights)

Explanatory variable		Dependent variable is: Domestic statutory tax rate				Domestic depreciation allowances			
		Theory	Coef.	Std.[a)]	Std.[b)]	Theory	Coef.	Std.[a)]	Std.[b)]
Foreign statutory tax rate	(1)	+	0,150	0,111	0,090 *	-	-0,658	0,221	0,066 ***
Foreign depreciation allowance	(2)	-	-0,552	0,159	0,145 ***	+	0,259	0,138	0,049 ***
Country size (log GDP)	(3)	+	0,113	0,034	0,025 ***	+	0,113	0,045	0,029 ***
Costs (log GDP-per-capita)	(4)	-	-0,436	0,093	0,093 ***	-	-0,281	0,129	0,074 ***
Trade costs (log index value)	(5)	+	0,501	0,052	0,040 ***	-	0,027	0,067	0,024
Observations			749				749		
Countries			43				43		
Estimation method			IV-2SLS				IV-2SLS		
Instrumentation:									
Shea's partial R^2 for identifying instruments to explain (1)			0,783				0,872		
Shea's partial R^2 for identifying instruments to explain (2)			0,874				0,927		
Over-identification (p-value of Sargan's χ^2-statistic)			0,187				0,169		
Exogeneity of (1) and (2) (p-value of Hausman-Wu-test)			0,000				0,000		
Fixed country effects (p-value of F-test)			0,000				0,000		

Notes: *** significant at 1%; * significant at 10%. - a) Newey-West-type standard errors which are robust to heteroskedasticity and autocorrelation. - b) Driscoll and Kraay-type standard errors which are robust to serial and spatial autocorrelation.

Table 3 - Reaction function estimation for coporate tax rates and depreciation allowances (inverse-distance-based third-country weights)

Explanatory variable		Dependent variable is							
		Domestic statutory tax rate				Domestic depreciation allowances			
		Theory	Coef.	Std.[a)]	Std.[b)]	Theory	Coef.	Std.[a)]	Std.[b)]
Foreign statutory tax rate	(1)	+	0,246	0,166	0,134 *	-	-0,438	0,128	0,157 ***
Foreign depreciation allowance	(2)	-	-0,439	0,119	0,099 ***	+	0,311	0,088	0,105 ***
Country size (log GDP)	(3)	+	0,100	0,037	0,027 ***	+	0,194	0,050	0,035 ***
Costs (log GDP-per-capita)	(4)	-	-0,411	0,130	0,123 ***	-	-0,851	0,223	0,161 ***
Trade costs (log index value)	(5)	+	0,188	0,051	0,048 ***	-	-0,075	0,037	0,062
Observations			749				749		
Countries			43				43		
Estimation method			IV-2SLS				IV-2SLS		
Instrumentation:									
Shea's partial R^2 for identifying instruments to explain (1)			0,408				0,669		
Shea's partial R^2 for identifying instruments to explain (2)			0,384				0,592		
Over-identification (p-value of Sargan's χ^2-statistic)			0,226				0,169		
Exogeneity of (1) and (2) (p-value of Hausman-Wu-test)			0,000				0,000		
Fixed country effects (p-value of F-test)			0,000				0,000		

Notes: *** significant at 1%; * significant at 10%. - a) Newey-West-type standard errors which are robust to heteroskedasticity and autocorrelation. - b) Driscoll and Kraay-type standard errors which are robust to serial and spatial autocorrelation.

Table 4 - Sensitivity analysis

Explanatory variable		Dependent variable is: Domestic statutory tax rate Coef.	Std.[a)]	Domestic depreciation allowances Coef.	Std.[a)]
		Using population instead of real GDP to measure country size			
Foreign statutory tax rate	(1)	0,188	0,104 *	-0,419	0,136 ***
Foreign depreciation allowance	(2)	-0,440	0,101 ***	0,260	0,085 ***
		Using wages instead of GDP per capita to measure production costs			
Foreign statutory tax rate	(1)	0,080	0,136	-0,422	0,159 ***
Foreign depreciation allowance	(2)	-0,373	0,104 ***	0,287	0,104 ***
		Using log c.i.f./f.o.b. ratios as a measure of trade costs (s)			
Foreign statutory tax rate	(1)	0,317	0,068 ***	-0,226	0,063 ***
Foreign depreciation allowance	(2)	-0,645	0,077 ***	0,187	0,038 ***
		Using contiguity weights to aggregate third-country tax parameters			
Foreign statutory tax rate	(1)	0,326	0,121 ***	-0,370	0,047 ***
Foreign depreciation allowance	(2)	-0,511	0,077 ***	0,105	0,027 **
		Using natural FDI weights to aggregate third-country tax parameters			
Foreign statutory tax rate	(1)	0,375	0,094 ***	-0,936	0,125 ***
Foreign depreciation allowance	(2)	-0,555	0,079 ***	0,433	0,049 ***

Notes: *** significant at 1%; * significant at 10%. - a) Driscoll and Kraay-type standard errors which are robust to serial and spatial autocorrelation.

Table 5 - Simulated impact of economic integration in 18 countries between 1982 and 2000
(Predictions are based on the model in Table 3)

Actual/predicted change in instruments	Statutory tax rates	Deprec. allowances
Actual average change in %	-18,10	5,62
Predicted average change in %	-15,68	1,71
Predicted average counterfactual change in %: FTA integration in 2000 as of 1982	-15,22	2,03
Change in % due to Nash-equilibrium-shifting trade costs (log index value) but not the reaction function[a)]	-15,07	1,74
Change in % due to the reaction function but not the Nash-equilibrium-shifting trade costs[b)]	-15,83	2,00
Predicted average counterfactual change in %: no FTA integration at all	-13,53	2,32
Change in % due to Nash-equilibrium-shifting trade costs (log index value) but not the reaction function[a)]	-13,51	1,74
Change in % due to the reaction function but not the Nash-equilibrium-shifting trade costs[b)]	-15,71	2,29

Notes: a) This assumes that the change in integration does not have an impact on predicted trade flows used for third-country-weights in Table 3 (i.e., it ignores the effect reported in Table A2) but only on the trade cost index used as a Nash-equilibrium-instrument-shifter in Table 3 (According to a least-squares regression model, a country's average fraction of FTA partners among the 43 economies reduces the trade cost index as expected; the parameter is -2.749 and the standard error is 1.438). - b) This assumes that the change in integration does have an impact on predicted trade flows used for third-country-weights in Table 3 (i.e., it takes into account the effect reported in Table A2) but not on the trade cost index used as a Nash-equilibrium-instrument-shifter in Table 3 (i.e., it ignores the aforementioned nexusbetween economic integration and the trade cost index).

Table 6 - Predicted coefficients of variation in tax instruments in benchmark and counterfactual (non-integration) situations
(Estimates are based on the results in Table 3 and for the 18 countries with data available both in 1982 and 2000)

Predicted coefficient of variation of	1982	2000	Interpretation
Benchmark (with FTA integration as observed)			
Statutory tax rate	0,254	0,229	Convergence
Depreciation allowance	0,216	0,088	Convergence
Counterfactual 1 (with EU and EFTA integration as of 1982; no NAFTA)			
Statutory tax rate	0,136	0,220	Divergence
Depreciation allowance	0,082	0,090	Divergence
Counterfactual 2 (without any EU, EFTA, or NAFTA integration)			
Statutory tax rate	0,082	0,092	Divergence
Depreciation allowance	0,137	0,215	Divergence

Table A1 - Descriptive statistics

Variable	Mean	Std.
Domestic statutory tax rate	34,855	10,863
Domestic depreciation allowance	43,637	10,585
Country size (log GDP)	25,491	1,957
Costs (log GDP-per-capita)	2,228	0,112
Trade costs (log index value)	-1,375	0,146

Notes: 749 observations; 43 countries.

Table A2 - Poisson pseudo-maximum likelihood regression to predict bilateral trade flows
(The dependent variable are nominal bilateral exports in U.S. dollars)

Explanatory variable	Coef.	Std.[a)]	
Log distance	-0,666	0,018	***
Adjacency indicator	0,376	0,029	***
Common language indicator	0,334	0,028	***
Free trade area indicator	0,544	0,022	***
Observations (country-pairs)	15.905		
Countries	43		
Fixed exporter and importer effects (p-value of Wald-test)	0,000		

Notes: *** significant at 1%. - The underlying data refer to cross-sectional averages over the period 1982-2000. a) Eicker-White-type standard errors which are robust to heteroskedasticity.